

1                   AUTOMOTIVE STEERING AND SUSPENSION SYSTEM

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3                   BACKGROUND OF THE INVENTION

4    1.   Field of the Invention

5                   The present invention generally relates to automotive  
6 drive systems and, more particularly, to such drive systems of the  
7 beam-type straight axle type.

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9    2.   Description of the Related Art

10                  Beam-type straight axle drive systems have been and still  
11 are commonly used for many different automotive applications.  
12 While simple in design, these axle types also tend to be  
13 inexpensive and very durable, making them highly desirable on  
14 utility vehicles such as pickup trucks and sport utility vehicles  
15 (SUVs) which are equipped with 4-wheel drive or, at least, power  
16 transmission to the front wheels.

17                  Many types of mounting and/or suspension methods have  
18 been used to attach straight axles to vehicles. Such methods  
19 include leaf springs, radius arms with coil springs, multi-link  
20 systems with coil springs, or a combination of any of the above.  
21 Probably the most compliant and well-functioning method of  
22 mounting/suspending a straight axle to a vehicle is the multi-link  
23 system in combination with coil springs. Vehicles such as the Jeep  
24 Cherokee (XJ Model), Jeep Comanche (MJ Model), Jeep Grand Cherokee  
25 (ZJ and WJ Models), Jeep Wrangler (TJ Model), and Dodge 4x4 pickup  
26 trucks have all used this type of system with reasonable success.

27                  The multi-link system of locating a beam-type straight  
28 axle commonly utilizes five different links: two upper suspension

1 arms, two lower suspension arms, and one track bar (see FIG. 1).  
2 The combination of these links enables the axle to move and  
3 articulate rather freely, while still providing a relatively stable  
4 platform for the vehicle to be suspended on.

5         Additionally, the steering system commonly utilized with  
6 this type of suspension system is the Y-type linkage (see FIG. 1).  
7 This system consists of a steering drag link running from the  
8 steering box pitman arm to the opposite steering knuckle, and a  
9 steering tie rod which attaches somewhere along the length of the  
10 steering drag link and on the opposite end to the remaining  
11 steering knuckle.

12         There are substantial problems with these types of  
13 suspension and steering systems. First, suspension compression  
14 results in axle translation, thus causing the vehicle to experience  
15 bump-induced yaw. When the vehicle hits a bump in the road, the  
16 suspension system will absorb this bump by allowing the axle to  
17 travel upward closer to the vehicle frame (see FIG. 2). As this  
18 happens, the track bar forces the axle toward the side of the  
19 vehicle opposite where the track rod attaches to the vehicle frame  
20 or body structure. This translation in axle location actually  
21 causes the vehicle body to move in the opposite direction (as the  
22 tires and wheels are mounted to the axle, and they will stay  
23 planted on the road surface), which is bump-induced yaw. This  
24 phenomenon creates a very unstable feel in the vehicle, possibly  
25 leading to loss of vehicle control. The problem is only  
26 exacerbated when the vehicle experiences increased suspension  
27 compression, such as during use in rough terrain.

1           Another significant problem lies with the Y-type steering  
2 linkage. As suspension compresses, the linkage changes its  
3 effective length, thus causing a toe-out situation with the tires.  
4 When the vehicle hits a bump in the road and the suspension  
5 compresses, the steering drag link and steering tie rod change  
6 relationship relative to one another (see FIG. 3). They become  
7 more parallel to one another during suspension compression, thus  
8 increasing the effective distance between the steering knuckles and  
9 thereby increasing toe-out on the vehicle (bump-induced toe  
10 change). Toe-out tends to make a vehicle "wander" or "hunt" around  
11 on the road, or in other words become unstable.

12           Jeep has somewhat resolved the bump-induced toe change  
13 problem on its later-model vehicles (WJ) by attaching the steering  
14 tie rod directly to both steering knuckles, rather than one  
15 steering knuckle and the steering drag link. However, there still  
16 remains an inherent problem with bump-induced steering, or  
17 bumpsteer. Referring to FIG. 1, it will be noted that the  
18 endpoints of the track rod do not coincide exactly with the  
19 endpoints of the steering drag link. As the vehicle hits a bump  
20 and the suspension compresses, these two linkage units move through  
21 somewhat different arcs. As the axle translates a given distance  
22 through a given amount of suspension compression, the steering  
23 knuckle translates a different amount. Thus, the vehicle will  
24 experience some amount of steering movement due solely to hitting  
25 the bump, which is bumpsteer.

26           Combining these three different issues together can cause  
27 a vehicle to handle very poorly during suspension compression,  
28 possibly leading to loss of vehicle control. A method of solving

1 these problems is highly desirable for people who own or plan to  
2 own any vehicle utilizing these suspension and steering systems.

### 3 4 SUMMARY OF THE INVENTION

5 In brief, particular arrangements of the present  
6 invention comprise a system of linkages which accurately control  
7 the vehicle steering as well as locate the axle throughout its full  
8 range of motion in a vertical plane when experiencing suspension  
9 compression. This system can be retrofit onto existing vehicles as  
10 a "bolt-on" improvement kit, thereby drastically improving the  
11 handling characteristics of such vehicles.

12 In one particular arrangement of the present invention,  
13 a pair of upper suspension arms, one connected to each front wheel,  
14 are secured together to a central tie point, thereby forming a  
15 "wishbone". The central tie point is attached to a frame member  
16 which attaches to the axle. This wishbone suspension and the  
17 associated steering linkage permit control of axle location in all  
18 axes while preventing any translation due to suspension  
19 compression, as is demonstrated in FIG. 2.

20 In another particular arrangement in accordance with the  
21 invention, the two upper suspension arms extend from the wheel  
22 mounting points to a pair of separate points fastened to the  
23 central plate which is attached to the axle, thereby providing the  
24 same effect as the wishbone of FIG. 4 with dual connecting points  
25 for the inner ends of the upper suspension arms. As with the  
26 first-mentioned embodiment, this arrangement also serves to control  
27 axle travel in all axes while preventing axle translation due to  
28 axle suspension compression.

1                    BRIEF DESCRIPTION OF THE DRAWINGS

2                    A better understanding of the present invention may be  
3 realized from a consideration of the following detailed  
4 description, taken in conjunction with the accompanying drawings,  
5 in which:

6                    FIG. 1 is an end elevational view of a conventional Y-  
7 type multi-link suspension and steering system for locating a beam-  
8 type straight axle; and

9                    FIG. 2 is an end elevational view of the system of FIG. 1  
10 showing the effects of suspension compression resulting in axle  
11 translation causing bump-induced yaw;

12                    FIG. 3 is an end elevational view of the system of FIG. 1  
13 showing increased toe-out of vehicle front wheels resulting from  
14 suspension compression;

15                    FIG. 4 is an end elevational view of one embodiment of  
16 the present invention, wherein the two lower suspension arms are  
17 similar to those in the existing design, but there is a single "V"-  
18 shaped upper arm called a "wishbone"; and

19                    FIG. 5 is an end elevational view of another embodiment  
20 of the present invention, wherein the two lower suspension arms are  
21 similar to those in the prior art design of FIG. 1, but two  
22 independent upper suspension arms are utilized to create an axle-  
23 centering feature similar to the wishbone link of FIG. 4.

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25                    DESCRIPTION OF THE PREFERRED EMBODIMENTS

26                    Referring to FIGs. 1-3, a common configuration of utility  
27 vehicle suspension and steering is shown. Any left and right  
28 references are used as a matter of convenience and are determined

1 by standing at the rear of the vehicle and facing forwardly in the  
2 direction of travel.

3 As depicted in FIG. 1, the multi-link system of locating  
4 a beam-type straight axle, as known in the prior art, commonly  
5 utilizes five different links: two upper suspension arms 10, two  
6 lower suspension arms 20, and one track rod 30. The combination of  
7 these links interconnected in the manner shown in the drawing  
8 enables the axle 40 to move and articulate rather freely, while  
9 still providing a relatively stable platform for the vehicle to be  
10 suspended on.

11 FIG. 1 also depicts a steering system commonly utilized  
12 with this type of suspension system, known as the Y-type linkage.  
13 This system consists of a steering drag link 50 running from the  
14 steering box pitman arm (not shown) to the opposite steering  
15 knuckle (not shown), and a steering tie rod 60 which attaches  
16 somewhere along the length of the steering drag link 50 and on the  
17 opposite end to the remaining steering knuckle (not shown).

18 FIG. 2 depicts the problems presented by commonly  
19 existing types of suspension and steering systems when the vehicle  
20 hits a bump in the road. The suspension system will compress to  
21 absorb the bump by allowing the axle 40 to travel upwards and  
22 closer to the vehicle frame (in the direction of the arrow 42). As  
23 this happens, the track bar 30 forces the axle 40 toward the side  
24 of the vehicle opposite where the track bar 30 attaches to the  
25 vehicle frame (to the left in FIG. 2, represented by the arrow 44).  
26 This translation in axle location causes the vehicle to move in the  
27 opposite direction, thereby creating bump-induced yaw.

1           FIG. 3 depicts another problem presented by the existing  
2 Y-type steering linkage when the vehicle hits a bump in the road.  
3 As the suspension system compresses (arrow 42) to absorb the bump,  
4 the steering drag link 50 and steering tie rod 60 change position  
5 relative to one another, becoming more parallel. This increases  
6 the effective distance between the steering knuckles (not shown) at  
7 the ends of steering drag link 50 and steering tie rod 60 and  
8 therefore increases toe-out on the vehicle (represented by the  
9 arrows 46). These changes in vehicle orientation on bumpy terrain  
10 contribute to vehicle instability.

11           FIG. 4 depicts a steering linkage system of the present  
12 invention which eliminates the noted problems to which existing  
13 steering systems are prone. A steering link (not shown) extends  
14 from the pitman arm 110 on the steering box back to a steering  
15 idler 120. This steering idler 120 provides a pivot which is  
16 substantially coincident with the frame pivot 132 of a wishbone  
17 130, thereby minimizing relative motion between the steering idler  
18 120 and the pitman arm 110 as the wishbone 130 is moved up and down  
19 throughout the vehicle's range of suspension travel, from full  
20 compression to full extension. A steering drag link 100 extends  
21 from the steering idler 120 to a steering bellcrank 140. The pivot  
22 of the steering bellcrank 140 is substantially coincident with the  
23 axle pivot of wishbone 130; therefore there is no relative motion  
24 between steering bellcrank 140 and steering idler 120 as  
25 wishbone 130 is moved up and down throughout the vehicle's range of  
26 suspension travel. Tie rods 150 extend from steering bellcrank 140  
27 to each of the steering knuckles (not shown). In this manner,  
28 there is no relative motion between steering knuckles (not shown)

1 and steering bellcrank 140, as they all attach to axle 40 via the  
2 frame pivot 132 and mounting plate 134.

3           It is not necessary that the steering idler 120 be  
4 coupled by a pivot on the wishbone 130. In an alternative  
5 embodiment, a sliding idler would be equivalent in result to the  
6 pivoted idler 120. This is because the idler is used to transmit  
7 motion from pitman arm 110 to the bellcrank 140 via the steering  
8 link and steering drag link 100. All that is required is that the  
9 idler be unaffected by motion of the wishbone. This result can be  
10 accomplished equally well by the idler 120, whether its coupling to  
11 the wishbone 130 is by means of a pivot or a slider.

12           With this system, all relative motion between linkage  
13 components is eliminated by making all relative pivot points  
14 substantially coincident with one another. Bump-induced toe change  
15 and bump-induced steering change are therefore completely  
16 eliminated.

17           This wishbone linkage can attach in one of two ways: two  
18 attachment points on the vehicle frame and one attachment point on  
19 the axle (as shown in FIG. 4) or reversed, with one attachment  
20 point on the frame and two attachment points on the axle. This  
21 wishbone linkage may also be located either on the top of the axle  
22 (as shown), or on the bottom of the axle utilizing upper suspension  
23 arms instead of lower suspension arms. The combination of two  
24 suspension arms and one wishbone allows control of the axle  
25 location in all axes without any translation due to axle suspension  
26 compression and articulation.

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1           FIG. 5 illustrates another embodiment of the present  
2 invention. Rather than using a single wishbone link, such as the  
3 wishbone 130 in FIG. 4, this embodiment incorporates two  
4 independent upper suspension arms 200. This embodiment could also  
5 be deployed as lower suspension arms 200'. By angling suspension  
6 arms 200 significantly inward toward axle 40, the suspension arms  
7 200 provide an axle-centering feature similar to the wishbone  
8 configuration depicted in FIG. 4. An alternative configuration  
9 could have upper suspension arms 200 substantially parallel and  
10 lower suspension arms 200' angled in relation to axle 40. The  
11 steering linkage is very similar to that in FIG. 4, as the pivots  
12 of the steering idler 120 and the steering bellcrank 140 coincide  
13 with the pivots of a single suspension link.

14           Yet another alternative configuration (not shown)  
15 involves leaving commonly occurring, stock multi-link setup (with  
16 two upper suspension arms 10, two lower suspension arms 20, and a  
17 track bar 30), but replacing the steering with a linkage system  
18 similar to that in FIG. 5. Such a configuration would have the  
19 pivots coinciding with one of the suspension arms (10 or 20) and  
20 the problems with bump-induced toe change and bumpsteer are  
21 eliminated, although bump-induced yaw would remain.

22           Although there have been described hereinabove various  
23 specific arrangements of a AUTOMOTIVE STEERING AND SUSPENSION  
24 SYSTEM in accordance with the invention for the purpose of  
25 illustrating the manner in which the invention may be used to  
26 advantage, it will be appreciated that the invention is not limited  
27 thereto. Accordingly, any and all modifications, variations or  
28 equivalent arrangements which may occur to those skilled in the art

1 should be considered to be within the scope of the invention as  
2 defined in the annexed claims.

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